

APPENDIX E
ESTIMATION OF REPRESENTATIVE
SOIL AND GROUNDWATER CONCENTRATIONS

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E.1 BACKGROUND

Application of the MRBCA process results in the calculation of target levels for each complete pathway identified in the exposure model (EM) and each chemical of concern (COC). Risk management decisions require these target concentrations to be compared with appropriate representative concentrations for the site.

The calculation of representative concentrations is complicated by several factors. These include (i) spatial variability in the concentrations, (ii) temporal variability in the concentrations, and (iii) lack of sufficient site-specific concentration data. This appendix discusses the methodology used to estimate the representative concentrations for each complete route of exposure.

E.2 CALCULATION OF REPRESENTATIVE CONCENTRATIONS

E.2.1 Surficial Soil (0-3 feet below ground surface)

The MRBCA process requires the evaluation of two routes of exposure associated with surficial soil. These are (i) the ingestion of chemicals in groundwater due to leaching of residual chemicals present in the surficial soil, and (ii) accidental ingestion of soil, outdoor inhalation of vapors and particulate from surficial soil emissions, and dermal contact with surficial soil. These pathways are referred to as the protection of groundwater and the direct contact pathway, respectively. Thus two different surficial soil representative concentrations are required. Note, however, that, depending on use of the site and characteristics of the area of release, a single representative concentration might suffice for both pathways.

E.2.1.1 Representative Surficial Soil Concentration for Protection of Groundwater

The representative surficial soil concentration should be calculated using the surficial soil data collected within the release area. Thus, prior to calculating the representative concentration, it is necessary to (i) clearly locate the horizontal dimensions of the release area, and (ii) identify the surficial soil data available within the release area. Refer to Section 5.8.1 for a definition of the release area.

E.2.1.2 Representative Concentrations for Direct Contact Pathway

The representative surficial soil concentration has to be based on the receptor's exposure domain, that is, the area of the site over which the receptor might be exposed to the surficial soil. The exact domain of the receptor is difficult to estimate especially since the domain has to be representative of a period of time equal to the receptor's exposure duration. However, in the absence of specific information about the receptor's activities, the unpaved portion of a site should be considered as the receptor's domain. For potential future exposures, assume that the pavement will be removed and exposure to surficial soil will occur. In such a case, the entire site should be considered as the receptor's domain.

To calculate the representative concentration for the direct contact pathway, one must (i) estimate the receptor's domain(s), and (ii) determine the number of soil samples available within this domain or the number of samples necessary to represent the domain. For a non-resident or a construction worker, the average concentration over the domain may be used. For a child receptor, the maximum concentration must be used and, therefore, a representative concentration need not be calculated if a child is an actual or potential receptor.

E.2.2 Subsurface Soil (greater than 3 feet below ground surface)

The MRBCA process includes the following two routes of exposure associated with subsurface soil: (i) leaching of residual COC concentrations in the subsurface soil to groundwater, and (ii) indoor inhalation of vapor emissions. Thus, a representative concentration must be calculated for each complete pathway. Additional representative concentrations are required if the receptor's domain differs under current and future conditions.

E.2.2.1 Representative Subsurface Soil Concentration for Protection of Groundwater

The representative concentration for this pathway should be the average concentration in subsurface soil measured within the area of release.

E.2.2.2 Representative Subsurface Soil Concentration for Protection of Indoor Inhalation

Subsurface soil concentrations protective of indoor inhalation are estimated using the Johnson and Ettinger (2001) model, excluding the advection component. This model assumes that chemicals volatilize from the subsurface soil source, travel vertically upwards without any lateral or transverse spreading, and enter the building through cracks in the foundation and floor. To ensure consistency with the model, the representative concentration for this pathway should be based on soil concentrations measured directly below the footprint of the enclosed space.

To evaluate the potential future indoor inhalation pathway, (i.e., an enclosed structure is constructed over contaminated soil), the size (footprint) and location of a hypothetical structure must be estimated. In the absence of site-specific information regarding planned structures, the future location and size of the structure must be approximated based on the evaluator's professional judgement. A conservative option is to locate the hypothetical structure over the area of release (i.e., the area of maximum COC concentrations). For tank sites, the default size of this structure is 30 ft by 30 ft. For sites where the footprint of a current on-site structure is or might be different from that of a structure erected in the future, a representative subsurface soil concentration must be calculated for both the current and potential future structure.

To estimate the representative subsurface soil concentration for the indoor inhalation pathway, the evaluator must: (i) identify the footprint of the structure within which the receptor is located, (ii) identify the footprint of the potential future enclosed structure, (iii) identify the soil concentration data available within each of these two footprints, and (iv) calculate the average of these concentrations. If sufficient data are not available within the footprint, data collected within 10 ft of the footprint may be used. In no case may data collected more than 10 ft away from the footprint be used.

If several samples within and adjacent to the footprint are available, more weight should be given to the samples collected within and close to the footprint. Two scenarios are possible: (i) the building footprint is located entirely within the contaminated area, and (ii) the building footprint is partially located within the contaminated area. For both scenarios, the representative soil concentration should be based on data collected within and no more than 10 ft. from the footprint of the building. In the second scenario, the representative concentration is effectively reduced because a portion of the structure lies over unimpacted soil.

E.2.3 Representative Concentration for Construction Worker

The MRBCA process requires the evaluation of the following three routes of exposure for the construction worker: (i) accidental ingestion, dermal contact, and outdoor inhalation of vapors and particulates from soil, (ii) outdoor inhalation of vapors from groundwater, and (iii) dermal contact with groundwater. Thus three representative concentrations are required. Each of these is discussed below.

E.2.3.1 Representative Soil Concentration

For the construction worker, no distinction is made between surficial and subsurface soil because, during construction, the construction worker might be exposed to both. To estimate the representative concentration for the construction worker, it is necessary to identify the (i) depth of construction, (ii) areal extent of construction, and (iii) the number of samples within the zone of construction. The potential future depth of construction should be estimated based on the likely type of structure that might be built and by identifying the typical depth of utilities on and adjacent to the site. If the areal extent of the construction area is not known, assume that the zone will be within the area of release. The representative concentration would be the averaged concentration within this zone of construction.

E.2.3.2 Representative Groundwater Concentration

As in the case of estimating representative groundwater concentrations, it is necessary to estimate the areal extent of the construction zone and identify the groundwater data available for this zone. The representative concentration would then be calculated as the average concentration within this zone. Temporal variations in groundwater concentrations should be evaluated as discussed in Section E.2.4.1.

E.2.4 Groundwater

The MRBCA process requires the evaluation of the following three routes of exposure associated with shallow groundwater: (i) ingestion of groundwater, (ii) dermal contact with groundwater, and (iii) indoor inhalation of vapor emissions from groundwater. Where multiple aquifers are present, the shallowest aquifer would be considered for the volatilization pathway. The specific aquifers that are or might be used for domestic use or in another manner in which dermal contact could occur must be considered for the ingestion and dermal contact pathways. Representative concentrations must be calculated for each aquifer this is or is reasonably likely to be used for domestic purposes. Thus, at least three different groundwater representative concentrations, one for each complete pathway, must be calculated.

E.2.4.1 Representative Demonstration Well Concentration for Protection of Groundwater Ingestion (Drinking Water Pathway)

For the ingestion of groundwater pathway, maximum contaminant levels (MCLs) or, where MCLs are lacking, other literature or calculated risk-based concentrations must be met at the point of exposure (POE) well. Often the point of exposure well is hypothetical and, therefore, data for the POE might not be available. In addition, one or more point of demonstration (POD) wells must be identified and target concentrations must be calculated for these wells.

The representative concentration at the POD or POE should be calculated based on measured COC concentrations, as discussed below:

- If COC concentrations in groundwater are stable, the representative concentration is the arithmetic average of the most recent data collected over a period of at least two years on at least a quarterly basis.
- If COC concentrations are decreasing, the representative concentration is the arithmetic average of the most recent data collected over a period of at least one and one-half years (6 months) on at least a quarterly basis.

E.2.4.2 Representative Groundwater Concentration for Protection of Indoor Inhalation

Groundwater concentrations protective of indoor inhalation are estimated using the Johnson and Ettinger (2001) model (without the advection component). This model assumes no lateral or transverse spreading of the vapors as they migrate upward from the water table through the capillary fringe and the vadose zone and into the enclosed space. Thus, representative concentrations for this pathway should be based on groundwater concentrations measured within the footprint of the building. Refer to Section E.2.2.2 for a discussion of the evaluation of future structures and their relationship to the impacted area.

For the groundwater to indoor air pathway, multiple representative concentrations might be needed if the plume has migrated below several current or potential future buildings. For example, if a plume has migrated or is likely to migrate below two different buildings, one on-site and one off-site, representative concentrations would have to be calculated for each.

Since the target groundwater concentrations for this pathway are based on the assumption of no lateral or transverse spreading of the vapors as they diffuse upwards to the building, the representative concentrations should be based on data collected within the footprint(s) of the structure(s). After identifying the location of the building footprints (whether real or hypothetical) and the available groundwater monitoring data within or adjacent to each footprint, the average concentration within each footprint must be estimated, as discussed in Section E.2.2.2. However groundwater data might not be available for each footprint, in which case it would be reasonable to install additional monitoring wells within the footprint lacking data, interpolate data between existing wells, or, as a conservative approach, use data from upgradient wells. (Note: In the case where the plume originates under a building, extrapolated data gathered from areas adjacent to the footprint might not be adequate.)

E.2.4.3 Representative Groundwater Concentration for Dermal Contact

The average concentration of COCs in the groundwater that a receptor might come in contact with is used as the representative concentration. Note that temporal variations in COC concentrations will be considered as discussed in Section E.3. More than one representative concentration might be needed where a receptor might contact groundwater from more than one aquifer or saturated zone.

E.3 GENERAL CONSIDERATIONS FOR CALCULATING REPRESENTATIVE CONCENTRATIONS

Calculating representative concentrations requires considerable professional judgement. Prior to performing the computations identified in Section E.2, the following should be considered:

- Evaluate whether the spatial resolution of the data is sufficient. While an exact number of samples cannot be specified herein due to the variability in conditions from site to site, data should be available from known or likely release areas and the various receptors' exposure domains.
- If the data are "old" (> 4 years old) and the COC concentrations exceed the Tier 1 risk-based target levels (RBTLs), or if a new spill has been documented or is suspected, new data should be collected. If sufficient new data are collected, the new data may be used for risk evaluation and the old data disregarded. A new release will always require the collection of additional data.
- Non-detect soil samples located at the periphery of the exposure domain of interest shall not be used.

- Non-detect samples located within the exposure domain of interest shall be replaced by half the detection limit.
- If multiple surficial soil samples and/or multiple subsurface soil samples are available from the same borehole within the domain of interest, the average concentration of these samples may be used.
- The maximum concentration of any COC may not exceed ten times the representative concentration. If this situation occurs, further evaluation and, potentially, remediation, will be required by MDNR.

The following considerations are necessary to evaluate representative groundwater concentrations:

- To account for temporal variations in groundwater concentrations, the representative concentration in a well may be estimated as:
 - For a demonstration well where the plume is stable or shrinking, the representative concentration is the arithmetic average of the most recent one to three year's measurements, provided that the measurements account for seasonal variation. When calculating the arithmetic average, any concentration below detection limits shall be replaced by half the detection limit.
 - Data from wells on the periphery of the exposure domain having COC concentrations consistently below detection limits shall not be used.
- For wells that contain or have contained free product within the most recent two years, the concentration representative of the well should be the effective solubility of the various chemicals representing the free product in the well. Table B-5 lists the effective solubility of selected chemicals in gasoline, diesel, and jet fuel.

Table E-1
Calculation of Representative Concentrations

Route of Exposure	Calculation of Representative Concentration
Surficial Soil (0-3 ft bgs)	
Soil concentration protective of leaching to groundwater or surface water body	Average of the surface soil concentrations collected within the area of release.
Direct contact with soil including ingestion of soil, dermal contact with soil, and the outdoor inhalation of vapors and particulates emitted by surficial soils	Average of the surface soil concentrations within exposure domain for non-residential receptor. <u>Maximum concentration</u> for residential receptor.
Subsurface Soil (> 3 ft bgs)	
Indoor inhalation of vapor emissions	Average of the subsurface soil concentrations collected below or within 10 ft of the real or hypothetical footprint of the building (Excluding concentrations below water table and capillary fringe).
Soil concentration protective of leaching to groundwater	Average of the subsurface soil concentration within the area of release (Excluding concentrations below water table and capillary fringe).
Groundwater	
Indoor inhalation of vapor emissions	Average of the groundwater concentrations around the footprint of the real or hypothetical building
Dermal contact with groundwater	Average of the groundwater concentrations that a receptor may come in contact with
Groundwater domestic use pathway	
• Concentration at POE	Average of the groundwater concentrations*
• Concentration at POD	Average of the groundwater concentrations*

* If the measured concentrations are stable, the representative concentration is the arithmetic average of the most recent eight consecutive measurements, of which no two shall be less than three months apart. If the measured concentrations are decreasing, the representative concentration is the arithmetic average of the most recent six consecutive measurements, of which no two shall be less than three months apart.